MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2016/2017 SESSION

PTH 0016 – MODERN PHYSICS AND THERMODYNAMICS

(All sections / Groups)

7 MARCH 2017
9.00 a.m. – 11.00 a.m.
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This question paper consists of 4 pages with 4 questions and an appendix.
2. Answer all questions.
3. Write your answers in the Answer Booklet provided.

Question 1

(a) A glass lens has a scratch-resistant plastic coating on it. The speed of light in the glass is $0.67c$ and the speed of light in the coating is $0.80c$ where c is the speed of light in a vacuum. A ray of light in the coating is incident on the plastic-glass boundary at an angle of 15.0° with respect to the normal. Calculate the angle (with respect to the normal) the ray transmitted into the glass. [2½ marks]

(b) A 45.0° prism has an index of refraction of 1.51. Light is normally incident on the prism as shown in Figure 1 below.

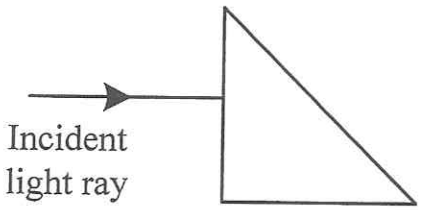

Figure 1

(i) Does light exit the back of the prism? If so, calculate the angle of refraction with respect to the normal. [2½ marks]

(ii) If not, what happens to the light? [1 mark]

(c) An object is placed 7.00 cm to the left of a converging lens of focal length 3.00 cm as shown in Figure 2 below. A convex mirror with a radius of curvature of 4.00 cm is placed 12.00 cm to the right of the lens.

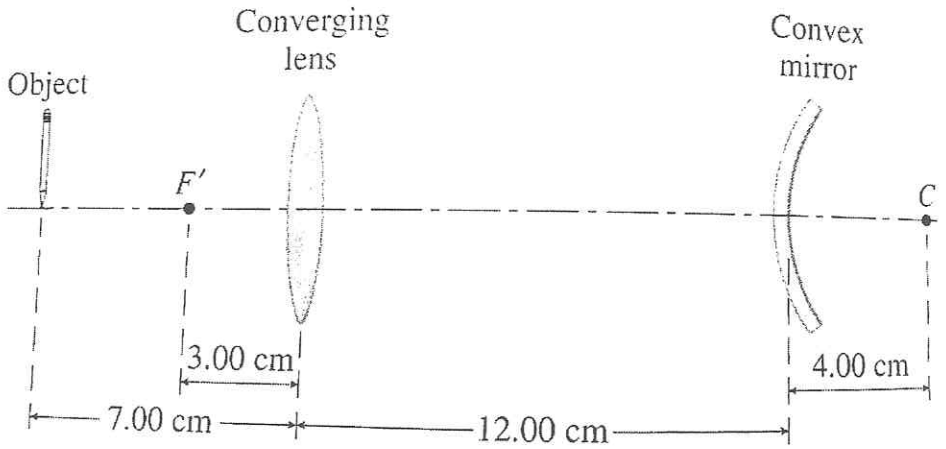

Figure 2

(i) Determine the location of the intermediate image formed by the lens. [1 mark]

(ii) Calculate the magnification due to the lens. [1 mark]

(iii) Is the intermediate image real or virtual? [½ marks]

(iv) Is the intermediate image upright or inverted with respect to the object? [½ marks]

(v) Determine the location of the image formed by the mirror. [1½ marks]

(vi) Calculate the magnification due to the mirror. [1 mark]

(vii) Is the second image real or virtual? [½ marks]

(viii) Is the second image upright or inverted with respect to the original object? [½ marks]

(ix) Calculate the total magnification. [1 mark]

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(d) Light of wavelength 589 nm incident on a pair of slits produces an interference pattern on a distant screen in which the separation between adjacent bright fringes at the centre of the pattern is 0.53 cm. A second light source, when incident on the same pair of slits, produces an interference pattern on the same screen with a separation of 0.64 cm between adjacent bright fringes at the centre of the pattern. Calculate the wavelength of the second source. [1½ marks]

Question 2

(a) Radiation from the sun has a wavelength of peak intensity of 500 nm. What is the sun's surface temperature in kelvin? [2 marks]

(b) (i) What do you understand by photoelectric effect? [1 mark]

(ii) In a photoelectric effect experiment, the emitter is connected to the negative terminal of a battery. Initially, the photoelectric current increases when the potential difference of the battery is increased. However, at some point, the current stops increasing and remains constant even though the potential difference is increased further. Explain why. [1 mark]

(iii) The work function of aluminium is 4.28 eV. What is the threshold frequency of aluminium? [2 marks]

(iv) An aluminium plate is illuminated with light of frequency 2×10^{15} Hz. What is the kinetic energy of a photoelectron emitted from the plate's surface? [2 marks]

(v) What is stopping voltage for (b)(iv) above? [2 marks]

Question 3

(a) A 150 mCi radioactive tracer is made in a nuclear reactor. When it is delivered to a hospital 16 hours later, its activity is 94.5 mCi. The lowest usable level of activity is 10 mCi. ($1\ \text{Ci} = 3.7 \times 10^{10}$ decays/s)

(i) What is the tracer's half-life? [3 marks]

(ii) For how long after delivery is the sample usable? [3 marks]

(iii) How many radioactive nuclei are there when the tracer is not usable anymore? [2 marks]

(b) The uranium isotope $^{233}_{92}\text{U}$ undergoes alpha decay. What are the mass number and atomic number of the daughter nucleus? [2 marks]

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Question 4

(a) What do specific heat capacity and specific latent heat of a substance mean? [2 marks]

(b) You pour 50 g of water at 25°C onto a 100-g ice cube at 0°C in an isolated system. Specific heat capacity of water is 4181.3 $Jkg^{-1}K^{-1}$. Specific latent heat of fusion of water is 3.34×10^5 Jkg^{-1}.

(i) Give a sensible range of the temperature θ when thermal equilibrium is reached. [1 mark]

(ii) Find the heat that the water should release for it to cool to 0°C. [2 marks]

(iii) Find the heat required to melt the entire ice cube. [2 marks]

(iv) Conclude the temperature when thermal equilibrium is reached. [1 mark]

(v) How many grams of the ice cube melts when thermal equilibrium is reached? [2 marks]

(c) A man dives into the bottom of a swimming pool. He then breathes out an air bubble. The density of water is 1000 kgm^{-3}.

(i) What can you say about the size of the bubble as it rises to the surface? Explain your answer. [2 marks]

(ii) The volume of the bubble when it is released is 1.5 cm^3. What is the radius of the bubble when it reaches the surface if the depth of the pool is 2.0 m? [3 marks]

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APPENDIX

LIST OF PHYSICAL CONSTANTS

Electron mass,	m_e	=	9.11×10^{-31} kg
Proton mass,	m_p	=	1.67×10^{-27} kg
Neutron mass,	m_n	=	1.67×10^{-27} kg
Magnitude of the electron charge,	e	=	1.60×10^{-19} C
Universal gravitational constant,	G	=	6.67×10^{-11} N m^2 / kg^2
Universal gas constant,	R	=	8.314 J/mol K
Hydrogen ground state,	E_0	=	13.6 eV
Boltzmann's constant,	k_B	=	1.38×10^{-23} J/K
Compton wavelength,	λ_c	=	2.426×10^{-12} m
Planck's constant,	h	=	6.63×10^{-34} J s
		=	4.14×10^{-15} eV s
Speed of light in vacuum,	c	=	3.00×10^{8} m/s
Rydberg constant,	R_H	=	1.097×10^{7} m^{-1}
Acceleration due to gravity of earth,	g	=	9.80 m/s^2
1unified atomic mass unit,	1 u	=	931.5 MeV/c^2
		=	1.66×10^{-27} kg
1 electron volt,	1 eV	=	1.60×10^{-19} J
Avogadro's number,	N_A	=	6.02×10^{23} mol^{-1}
Threshold of intensity of hearing,	I_0	=	1.0×10^{-12} W/m^2
Coulomb constant,	$k = \frac{1}{4\pi\varepsilon_0}$	=	9.0×10^{9} N m^2 /C^2
Permittivity of free space,	ε_0	=	8.85×10^{-12} C^2/N m^2
Permeability of free space,	μ_0	=	$4\pi \times 10^{-7}$ T m/A
1 atmosphere pressure,	1 atm	=	1.013×10^{5} N/m^2
		=	1.013×10^{5} Pa
Wien's displacement constant		=	2.90×10^{-3} mK
Speed of sound in air		=	343 m/s
Refractive index of air/vacuum	n	=	1.0
Earth: Mass,	M_E	=	5.97×10^{24} kg
Radius (mean),	R_E	=	6.38×10^{3} km
Moon: Mass,	M_M	=	7.35×10^{22} kg
Radius (mean),	R_M	=	1.74×10^{3} km
Sun: Mass,	M_S	=	1.99×10^{30} kg
Radius (mean),	R_S	=	6.96×10^{5} km
Earth-Sun distance (mean),		=	149.6×10^{6} km
Earth-Moon distance (mean),		=	384×10^{3} km

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